



What is driving economic and financial success of US cow-calf operations?

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Abstract

Purpose – The purpose of this paper is to determine the drivers of economic financial success of US cow-calf operations.

Design/methodology/approach – This research uses a system of equations (DuPont analysis) in conjunction with 2008 farm-level data from the US Department of Agriculture's Agricultural Resource Management Survey to evaluate the factors driving cow-calf profitability, namely net profit margins, asset turnover ratio, and asset-to-equity ratio.

Findings – The study finds that the main drivers of return on equity are region, number of harvested acres on the farm, diversification of the farm, operator off-farm work, spousal off-farm work, and adoption of technologies. Of these factors, those for which producers can make short-term adjustments include off-farm work decisions and adoption of technologies. Longer-term adjustments can be made for farm diversification.

Originality/value – To the authors' knowledge, no existing research has used farm-level data across US production regions to examine the factors affecting returns to equity of US cow-calf operations. These research results may be used to identify strategies producers can use to improve their farm's economic viability, areas where extension services can assist farmers in making better financial decisions and economic factors that are likely to lead to structural changes in the beef industry.

Keywords Asset turnover, Asset-to-equity, Cow-calf operations, DuPont analysis, Profit margin, US beef industry

Paper type Research paper

Introduction

The cow-calf segment of the USA beef industry is diverse in terms of farm size and structure, as well as goals that motivate its producers. As such, cow-calf farms vary

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widely in economic and financial viability. While studies have examined cow-calf producer technology adoption patterns (Ward *et al.*, 2008; Kim *et al.*, 2008), economic efficiency (Featherstone *et al.*, 1997; Samarajeewa *et al.*, 2012), goal structure (Basarir and Gillespie, 2006; Gillespie and Mishra, 2011), and factors affecting profitability (Miller *et al.*, 2001; Ramsey *et al.*, 2005) mostly via regional analyses, few studies (McBride and Mathews, 2011) have focussed on the drivers of economic and financial viability of US cow-calf production on a national basis. Cow-calf farms have historically realized returns that have often either barely or not covered costs (Basarir and Gillespie, 2006), complicated further by systematic increases and decreases in cattle prices over time as illustrated by the roughly ten-year cattle cycle (Tomek and Robinson, 1981, p. 179). Thus, determination of drivers of cow-calf farm economic success is of particular interest. The objective of this paper is to determine the factors leading to improved return on equity (ROE) as measured by three components, solvency, profitability, and asset efficiency in the US cow-calf segment of the beef industry. Research results may be used to identify strategies producers can use to improve their farm's economic viability; areas where extension services can assist farmers in making better financial decisions; and economic factors that are likely to lead to structural change in the beef industry.

We use farm-level data for US cow-calf operations to evaluate what is driving the economic and financial success of cow-calf operations (Mishra *et al.*, 2009). To our knowledge, no one has used farm-level data across the US cow-calf production regions to examine the drivers of ROE. This study uses Agricultural Resource Management Survey (ARMS) farm-level data, the DuPont expansion model, and seemingly unrelated regression (SUR) methods to identify key factors affecting the ROE of cow-calf operators. It therefore more completely reflects the diversity of the cow-calf segment of the US beef industry.

The paper proceeds as follows. We first provide background information on the cow-calf segment of the beef industry. We then present the DuPont financial model which includes inverse solvency, profitability, and asset efficiency equations, as well as discuss the data. Finally, we present the results and conclusions.

Background

In 2007, the US cow-calf segment included an estimated 766,350 operations with 32.9 million cows (US Department of Agriculture, National Agricultural Statistics Service, 2008, 2010), for an average farm size of 43 cows. Most of these farms were relatively small-scale, with 53 percent having < 20 cows and almost 80 percent having < 50 cows (McBride and Mathews, 2011). Of those with ≥ 20 cows, considered commercial farms, about 7 percent had ≥ 250 cows; these farms held 35 percent of the total US cow inventory (McBride and Mathews, 2011). There has long existed a wide range in farm size within the cow-calf segment of the beef industry and, assuming economies of size, opportunities for smaller-scale producers to improve financial performance.

Evidence suggests that economies of size may be realized in the cow-calf sector. McBride and Mathews (2011) plotted operating costs, operating plus capital costs, and total economic costs for five size categories of cow-calf farms using 2008 cow-calf ARMS data. Other studies showing evidence of economies of size in cow-calf production include Langemeier *et al.* (1996), Short (2001), and Ramsey *et al.* (2005). However, as pointed out by Samarajeewa *et al.* (2012), herd size is by no means the only factor impacting production efficiency (as opposed to asset efficiency),

suggesting that a number of other factors also impact financial performance. McBride and Mathews (2011) point out that operating costs and operating costs per cow do not differ greatly on farms between the 50-99 cow and 200-499 cow herd sizes and that use of various technologies, management practices, and production systems (TMPPS), as well as farm income diversification, vary significantly by farm size. For instance, if one divides “cattle sales” by “gross cash income” in their study, results suggest that farms with 20-49 and ≥ 500 cows had 27 and 50 percent, respectively, of gross cash income from cattle sales, showing large differences in diversification by farm size. Their results suggest to us that work should be done to tease out the impacts of farm size from the other factors.

Not only are cow-calf farms highly diverse in size, but they are also diverse in goal structure of the operator. Basarir and Gillespie (2006) showed that Louisiana cow-calf producers were more likely than milk producers to choose “maintain and conserve land” as their top goal and less likely to choose “maximize profit” as their top goal. Furthermore, they found goal structure to differ by cow-calf farm size. Gillespie and Mishra (2011) showed that, unlike crop and broiler producers, cattle producers were more likely to answer that they had entered farming to “invest in real estate” or for “outdoor activity” than to “develop a business to generate additional income.” While Basarir and Gillespie’s (2006) “maintain and conserve land” and Gillespie and Mishra’s (2011) “invest in real estate” are not necessarily inconsistent with the goal of maximizing profit, differences in goal structure are evident. These differences in goal structure are likely due to relatively limited economies of size associated with this enterprise. Farmers can own small numbers of cows for additional income, to help maintain land, or for largely recreational purposes.

Weight at which an animal is sold impacts the return the farmer receives. In the past, calves were weaned at 350-450 pounds and then moved directly to feedlots for finishing. This strategy of selling lightweight calves was influenced by the relatively low price of corn in feedlot rations. As corn prices have increased in recent years, the response of feeders has been to seek heavier-weight cattle for entry into feedlots (*Feedstuffs*, 2012a, b). Stockering involves grazing calves to heavier weights after they have been weaned, but prior to selling. In the Southern USA, stockering generally takes place on high-quality winter annual pastures. Success of this heavier weight strategy depends on good climatic conditions for winter pasture and some fall hay stocks. A relatively small percentage of cow-calf producers finish cattle to slaughter weight on forage alone.

Other influences on financial viability include technological, managerial, and environmental factors. Technological and managerial factors in the case of cow-calf production refer to the use of artificial insemination, record-keeping systems, and others to be discussed in more detail.

The DuPont model and the data

Sound financial analysis is an integral part of managing a farm business, and the DuPont ratio developed by the DuPont Corporation is an excellent way to obtain a snapshot of the overall financial performance of three critical areas of financial ratio analysis: profitability, asset efficiency, and leverage (solvency ratio). The analysis allows analysts to identify strengths and weaknesses in these three areas. The approach is not only useful in corporate finance, but also for analyzing farm business performance. Collins (1985) introduced a slight variation of the DuPont formulation

which has become popular in agricultural finance research. The DuPont identity allows the decomposition of ROE into earnings, asset turnover, and leveraging decisions (solvency ratio). Using the identity, estimates of these three financial ratios are based on the following equation:

$$ROE = \text{Operating Profit Margin} \times \text{Asset Turnover} \times \text{Leverage}. \quad (1)$$

We use the DuPont model presented by Mishra *et al.* (2009) to analyze the relationship between the rate of ROE, asset efficiency, profitability, and inverse solvency, as shown in (2):

$$\frac{R}{E} = \frac{S - C}{S} \times \frac{S}{A} \times \frac{A}{E} \quad (2)$$

where R is agricultural sales S less production costs C , E is agricultural equity, and A is the value of agricultural assets. Thus, there are three main components of the ROE: profitability, asset efficiency, and solvency. Return on equity (R/E) is measured as the product of the farm's profitability, or its operating profit margin ratio (R/S); the farm's asset efficiency, or its asset turnover ratio (S/A); and the farm's solvency (in our case inverse solvency), or the inverse of the equity/asset ratio (A/E).

The rate of ROE (the farm's rate of net return to farm business equity) equals the farm's rate of return on assets (R/A) if the farm is debt-free; otherwise, interest must be paid on the debt, which is subtracted from net farm income R , and $A > E$. As a measure of profitability, a higher rate of ROE is preferred. As another measure of profitability, a higher operating profit margin ratio is desirable. As costs increase relative to sales, the operating profit margin decreases.

The farm's asset efficiency measures how quickly farm gross revenues cover the capital that has been invested in farm assets. If, for example, the asset turnover equals 0.20, then it would take five years for farm gross revenues to cover the amount invested in assets, so a higher asset turnover ratio is desired. Finally, solvency indicates whether the farm's liabilities could be met if its assets were sold. Solvency as measured by the equity/asset ratio measures the owner's equity capital as a portion of the farm's total assets, so a higher equity/asset ratio is preferred. In our model, inverse solvency is measured, so a lower asset/equity ratio would be preferred. Kay *et al.* (2012) provides more information regarding these measures of profitability, asset efficiency, and solvency.

As shown by Mishra *et al.* (2009), the DuPont model is linear in logs, as follows:

$$\ln\left(\frac{R}{E}\right) = \ln\left(\frac{R}{S}\right) + \ln\left(\frac{S}{A}\right) + \ln\left(\frac{A}{E}\right) \quad (3)$$

Given (3), a model for analyzing determinants of farm financial well-being estimates the farm's ROE, operating profit margin ratio, asset turnover ratio, and equity/asset ratio as a system in a SUR, with these measures serving as dependent variables in a system that corrects for the correlation of the error terms. Since $\ln(R/S)$, $\ln(S/A)$, and $\ln(A/E)$ sum to $\ln(R/E)$, the latter can be dropped from the system due to summing-up conditions, similar to Mishra *et al.* (2009).

Factors hypothesized to impact farm financial viability

The three equations estimated using SUR include the following, with definitions of the independent variables to follow:

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$$\ln\left(\frac{R}{S}\right) = f(\text{Appalachia, Southeast, North Central, Northern Plains, West,} \\ \text{Harvested Acres, Cows, Proportion Beef, Stocker, Finisher,} \\ \text{Operator Off-farm, Spouse Off-farm, Age, Breeding, Feed, Systems,} \\ \text{General Farm Management, Regions} \times \text{Cows, Regions} \times \text{Technology,} \\ \text{Regions} \times \text{Proportion Beef, Regions} \times \text{Harvested Acres}) \quad (4)$$

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$$\ln\left(\frac{S}{A}\right) = f(\text{Appalachia, Southeast, North Central, Northern Plains, West,} \\ \text{Harvested Acres, Cows, Proportion Beef, Stocker, Finisher, Operator} \\ \text{Off-farm, Spouse Off-farm, Age, Breeding, Feed, Systems, General} \\ \text{Farm Management, Regions} \times \text{Technology, Regions} \times \text{Proportion Beef,} \\ \text{Regions} \times \text{Stocker, Regions} \times \text{Finisher}) \quad (5)$$

$$\ln\left(\frac{A}{E}\right) = f(\text{Appalachia, Southeast, North Central, Northern Plains, West,} \\ \text{Harvested Acres, Cows, Proportion Beef, Stocker, Finisher,} \\ \text{Operator Off-farm, Spouse Off-farm, Age, Breeding, Feed, Systems,} \\ \text{General Farm Management, Regions} \times \text{Technology, Regions} \times \text{Stocker,} \\ \text{Regions} \times \text{Finisher}) \quad (6)$$

Two[1] variables are used to measure farm size: *Harvested Acres* and *Cows*. *Harvested Acres* refers to the number of acres on the farm where any crop (including hay) was harvested, a proxy for the land suitable for crops. In addition, *Harvested Acres* may serve as a proxy for reduced reliance on purchased feed and/or higher land quality, either or both expected to improve financial performance. *Cows* is the maximum number of beef cows on the farm during 2008, used to measure the impact of the size of the cow-calf enterprise on financial measures. Mishra *et al.* (2012) found that farm size was associated with profitability and asset efficiency. Furthermore, economies of size in the industry would suggest greater profitability and asset efficiency of larger-scale firms. Ramsey *et al.* (2005) showed a positive impact of greater breeding cow inventory on return on assets for cow-calf farms.

Proportion Beef is calculated as the farm's total value of beef produced divided by total value of production, a measure of farm diversification. Using an alternative measure of farm diversification (a count of commodities produced on the farm), Mishra *et al.* (2012) found that diversification influenced farm profitability, asset efficiency, and solvency. The impact of diversification would depend upon whether significant economies of scope exist in the industry or whether there are gains

associated with specializing in cow-calf production. Two variables indicate the phases of cattle production in which the farm is involved, both serving as measures of vertical integration. *Stocker* is a dummy variable indicating that animals were grazed on forage post-weaning to put additional weight on the animal prior to finishing. *Finisher* is a dummy variable indicating that animals were raised to slaughter weight on the farm. The impact of vertical integration on farm financial well-being is specific to the industry, impacted by transaction costs, risk, and gains from specialization in a specific industry segment. Williamson (1971) addressed a number of factors that determine whether vertical integration is advantageous to a firm.

Operator Off-farm and *Spouse Off-farm* indicate the annual value of work off-farm for the operator and spouse, respectively, in 2008. Gillespie and Mishra (2011) showed the importance of off-farm work in cow-calf farmers' reasons for entering farming. Since these variables were considered likely to be endogenously determined with farm financial variables, instrumental variables for each were estimated and Hausman (1978) tests run. Results indicated the presence of endogeneity, so instrumental variables were included in the model. Results of the ordinary least squares models to estimate the instrumental variables, which were predicted values from the models, are shown in Table A1. Independent variables included in the models to estimate the predicted *Operator Off-farm* were *Age*, farm net worth, government payments received by the farm, farm acres operated, the operator's holding a college degree, household size, accrued interest, off-farm interest income, population accessibility, value of livestock production under production contract, farm operator household assets, a household well-being index ranging from lower income and lower wealth to higher income and higher wealth, and total animal units on the farm. Eight of the 13 variables were significant at $p < 0.10$. Variables in the instrumental variable ordinary least squares run to estimate the predicted *Spouse Off-farm* were the same as for *Operator Off-farm* except the spouse's age and the household well-being index were not included while the off-farm wages or salaries earned by the household and the ratio of owned to operated farm acres were included. Seven of the 12 variables were significant at $p < 0.10$. R^2 values for both equations were 0.20, but numerous significant drivers indicated the predicted values could be reasonably used as instruments. Specification of these equations was influenced heavily by previous literature that has estimated operator and spouse off-farm work equations, such as Gillespie and Mishra (2011). Off-farm work can generally be expected to increase financial resources available to the farm, i.e. greater solvency. However, if less time is spent managing the farm, lower profit may result.

Age is the farmer's age in years. Mishra *et al.* (2012) found that the asset efficiency of older farmers was lower. It is expected that older producers would be more solvent, given they would be less likely to take on greater debt. Though age has been found to be negatively correlated with profitability for some farm enterprises, such as dairy (Gillespie *et al.*, 2009), the a priori expectation for cow-calf production is unclear since experience could be a significant driver for this less management and capital-intensive enterprise.

Four dummy variables, *Breeding*, *Feed*, *Systems*, and *General Farm*, were used to indicate farmers' use of advanced technologies, management systems, and production systems. *Breeding* indicates the producer adopted one or more of the following advanced breeding technologies: artificial insemination, sexed semen, or embryo transfer. *Feed* indicates the producer adopted one or more of the following feeding technologies

and management practices: implants/ionophores, hired a nutritionist to design feed mixes, or tested forage quality. *Systems* indicates the producer used a rotational grazing system and/or a calving season. *General Farm* indicates the producer used one or more of the following management practices: scheduled regular veterinarian visits, kept individual animal records, used a computer for keeping farm records, used the internet farm information, or utilized an animal identification system. Each of these variables indicates that the farmer used advanced TMPPS on their farms. Though limited research has thoroughly addressed the impact of specific technologies, management practices, and technologies on cow-calf enterprise profitability, Ramsey *et al.* (2005) showed a positive impact of calving percentage (which should be positively influenced by the use of better management practices) on return on assets.

Five regions were included in the analysis: *Appalachia*, *the Southeast*, *the North Central*, *the Northern Plains*, and *the West*. States included in *Appalachia* were US states surveyed in the 2008 ARMS, cow-calf version: AR, KY, TN, and VA. States included in the *Southeast* included AL, FL, GA, and MS. States included in the *North Central* included IA and MO. States included in the *Northern Plains* included KS, NE, ND, and SD. States included in the base *West* included CA, CO, OK, OR, MT, NM, TX, and WY. Cow-calf production varies by region of the USA. In Table I, we see that the *Northern Plains* had about 30 percent of the total value of US cow-calf production in 2008 (using a whole farm analysis and hence, including crop production), with the *West* accounting for 25 percent, the *North Central* and *West* close to 20 percent each, and *Appalachia* and the *Southeast* 14 and 12 percent, respectively. Cow-calf numbers per commercial farm (≥ 20 cows) were highest in the *Northern Plains* with > 100 cows per farm, followed by 98 in the *West*, and < 70 in *Appalachia*, the *Southeast* and the *North Central* regions. Use of purchased feed was lowest in the *North Central* and *Appalachian* regions and the *North Central* dominates in area devoted to corn production, underscoring the diversity of the five regions. Stockering and finishing in combination with cow-calf production were highest in the *North Central* and *Northern Plains* and lowest in *Appalachia* and the *Southeast*. Off-farm income relative to total income was notably lower in the *North Central* and *Northern Plains* compared to *Appalachia*, the *Southeast*, and the *West*. Traditional financial measures of return on assets and household returns also indicate higher returns in the *North Central* and *Northern Plains* compared to *Appalachia*, the *Southeast*, and the *West*.

A number of the independent variables were crossed with regional variables in the model. These crosses were included if it could be hypothesized that there was an interaction between the independent variable and region in determination of the financial measure and the β estimate was substantively larger than its standard error for at least one of the regional crosses with the independent variable, suggesting a possible impact. McBride and Mathews (2011) showed significant differences in cow-calf production by region, likely the result of different production conditions influencing enterprise mix; relative profitability associated with vertically integrating into stocking and/or finishing; optimum farm size; and the relative applicability of TMPPS by region. Thus, these factors are the focus of cross-effects by region. In the case of the technology variables, a dummy variable indicating that seven or more of the 12 TMPPS listed above in the technologies section were adopted was included in cross-terms with regions. This was done to avoid crossing all four of the technology variables with regions. Seven technologies were included to indicate the farm was in the 75th percentile of technology adoption.

Item	Appalachia	Southeast	North central	Northern plains	West
<i>General statistics by region</i>					
Number of observations	366	287	182	353	776
% of US farms	20.2	11.5	15.7	16.5	36.1
% of value of production of US farms	11.8	13.7	19.4	30.1	25.1
<i>Means by region</i>					
Household net return on assets	4.2	3.7	6.0	5.7	4.1
Return on assets	0.6	1.6	2.8	3.2	0.1
Acres operated	348	640	518	2,019	2,103
Number of cows	61	70	56	108	98
Age of operator	59.6	63.2	58.3	57.3	60.9
% of income from beef	34	17	23	38	66
% of acres operated that is not harvested acres	70.0	80.0	48.8	72.1	92.8
% of harvested acres in corn	8.8	4.1	32.1	17.1	5.5
Hay yield (tons/acre)	2.3	2.3	2.3	1.8	2.1
Potential pasture acres per cow	4.0	6.4	4.5	13.5	19.9
% of total feed that is purchased	36.9	46.8	38.8	46.4	61.5
Variable costs per cow	571	1,021	1,404	1,161	727
% of farms with stockers	20.2	18.6	23.7	42.7	27.7
% of farms with finishers	4.0	2.3	16.3	17.0	7.1
Operator off-farm hours	564	611	631	470	644
Spouse off-farm hours	574	543	683	631	591
% of total income from off-farm sources	39.0	35.2	22.3	13.9	38.7
Land price (\$/acre)	2,843	3,065	2,704	776	996
Number of the 12 technologies adopted	2.7	2.3	3.5	4.2	3.6
% of farms adopting ≥ 7 technologies	0.29	0.23	0.41	0.56	0.45
% of farms adopting ≥ 1 of the breeding technologies	4.1	3.9	10.8	17.0	8.1
% of farms adopting ≥ 1 of the feeding technologies	17.1	14.0	39.5	47.7	27.1
% of farms adopting an advanced production system	76.4	73.8	93.4	93.1	78.8
% of farms adopting ≥ 1 general farm management practices	78.1	67.3	91.9	93.7	92.6
DuPont inverse solvency (A/E)	1.04	1.02	1.12	1.12	1.05
DuPont profitability (R/S)	10.6	25.4	21.2	19.5	2.1
DuPont efficiency (S/A)	5.6	6.3	13.2	16.4	6.0
DuPont return on equity (S/E)	0.6	1.6	3.1	3.6	0.2

Table I.
Economic and technical
data: means and general
statistics by region

Using ARMS data to estimate the DuPont SUR

This study uses data from the 2008 ARMS Phase III cow-calf version, conducted by the USDA's National Agricultural Statistics Service and Economic Research Service. The 2008 data set provides 1,964 usable responses from 22 states, including 429 from *Appalachia*, 224 from the *Southeast*, 182 from the *North Central*, 353 from the *Northern Plains*, and 776 from the *West*. The ARMS collects information on farm size, type and structure; income and expenses; production practices; and farm and household characteristics. Because this design-based survey uses stratified sampling, weights or expansion factors are included for each observation to extend results to the population of US cow-calf operations, representing 90 percent of US cow-calf production.

Since complex stratified sampling is used with ARMS, inferences regarding variable means for regions are conducted using weighted observations. The ARMS is a multiphase, nonrandom survey, so classical statistical methods may yield naïve standard errors, causing them to be invalid. Each observation represents a number of similar farms based upon farm size and land use, which allows for a survey expansion factor or survey weight, effectively the inverse of the probability that the surveyed farm would be selected for the survey. As such, USDA-NASS has an in-house jackknifing procedure (Dubman, 2000) that is appropriate for use when analyzing ARMS data, which allows for valid inferences to the population. We use the jackknife replicate weights in SAS to obtain adjusted standard errors. A property of the delete-a-group jackknife procedure is that it is robust to unspecified heteroscedasticity.

The USDA version of the delete-a-group jackknife ARMS survey design divides the sample into 30 nearly equal and mutually exclusive parts. In total, 30 estimates of the statistic (replicates) are created. One of the 30 parts is eliminated in turn for each replicate estimate with replacement. The replicate and the full sample estimates are placed into the jackknife formula:

$$\text{Standard Error}(\beta) = \left\{ 29/30 \sum_{k=1}^{30} (\beta_k - \beta)^2 \right\}^{1/2} \quad (7)$$

where β is the full sample vector of coefficients from the SUR program results using the replicated data for the “base” run. β_k is one of the 30 vectors of regression coefficients for each of the jackknife samples. The t -statistics for each coefficient are computed by dividing the “base” run vector of coefficients by the vector of standard errors of the coefficients.

Results

Table I presents the means of variables of interest by region and Table II presents results of the DuPont SUR model. SUR was appropriate for this model since different variables were included in each equation and the Breusch-Pagan test showed that cross-equation error terms were correlated. The Berndt system adjusted R^2 for the SUR model was 0.3670. Examining the regional results for the four financial measures in Table I, Southeastern farms were numerically more solvent and profitable, while North Central and Northern Plains farms had numerically greater asset efficiency and ROE. Note that ROE for each region is the sum of inverse solvency, profitability, and asset measures in the log form of the DuPont model.

Examining the main effects of the regression model by region (Table II), only *Appalachia* was significant, suggesting that Appalachian farms were more profitable and solvent and less asset-efficient than Western farms. Furthermore, since *Appalachia* was significant in all three equations, we calculate its impact on ROE as the sum of its three parameter estimates in the respective equations: 0.46[2]. This suggests that Appalachian farms had higher ROE than Western farms. Regional results will be further discussed in the following paragraphs along with farm descriptor variables for which there were regional cross-effects estimated.

Farm size had limited impact on financial viability, with only asset efficiency being positively impacted by *Harvested Acres* in the main effects. It is noted, however, that in the *Northern Plains*, *Harvested Acres* had a greater positive impact on profitability relative to the *West*, where there is less land in feed grains and hay that can be utilized by the beef operation and less crop stubble for grazing. Overall, results suggest

Independent variable	Profitability (R/S)		Efficiency (S/A)		Inverse solvency (A/E)	
	β	SE	β	SE	β	SE
Constant	-0.6366	1.7854	2.4991*	1.4102	1.6243***	0.3266
Appalachia	0.9132*	0.5659	-0.4219***	0.1104	-0.0361**	0.0150
Southeast	0.6644	0.6020	-0.2562	0.1786	-0.0250	0.0169
North central	0.2808	0.6009	-0.2050	0.1938	0.1015	0.0616
Northern plains	0.2331	0.7873	0.0284	0.1625	-0.0067	0.0185
Harvested acres	0.0510	0.0426	0.0509***	0.0171	-0.0008	0.0023
Cows	0.1265	0.1036	-0.0055	0.0436	-0.0132	0.0105
Proportion beef	-0.3174	0.2464	-0.8988***	0.1284	-0.0239	0.0158
Stocker	-0.1198	0.1001	-0.0524	0.0901	0.0253	0.0171
Finisher	-0.0246	0.1571	-0.1842	0.1781	-0.0436*	0.0218
Pr-operator off-farm	0.2003***	0.0500	-0.0688	0.0455	-0.0252**	0.0089
Pr-spouse off-farm	-0.0479	0.0430	0.0855*	0.0372	0.0237***	0.0047
Age	0.6270*	0.3636	-1.2392***	0.2982	-0.3609***	0.0693
Breeding	-0.0622	0.1518	-0.1070	0.1013	-0.0303*	0.0175
Feed	-0.1040	0.1490	0.1437*	0.0664	0.0398**	0.0138
Systems	-0.0800	0.1407	-0.0483	0.0840	-0.0033	0.0126
General farm	0.1612	0.1747	0.1435*	0.0892	0.0044	0.0150
AP \times cows	-0.1678	0.1482				
SE \times cows	-0.2581*	0.1493				
NC \times cows	0.2369*	0.1229				
NP \times cows	0.0269	0.1280				
AP \times technology	-0.5028*	0.2398	0.1579*	0.0980	0.0189	0.0205
SE \times technology	-0.0859	0.2939	-0.0721	0.1704	0.0315	0.0335
NC \times technology	0.0463	0.2678	0.0199	0.1352	-0.0026	0.0372
NP \times technology	-0.0459	0.2352	0.0392	0.1246	0.0096	0.0239
AP \times proportion beef	0.6920**	0.3372	0.8386***	0.1801		
SE \times proportion beef	1.6721***	0.5151	0.6922**	0.2885		
NC \times proportion beef	0.4871	0.5293	0.5931*	0.3398		
NP \times proportion beef	0.4850	0.3052	0.7663***	0.2286		
AP \times stocker			0.0636	0.1631	0.0048	0.0295
SE \times stocker			-0.0079	0.1278	-0.0320	0.0248
NC \times stocker			0.1523	0.1535	-0.1213*	0.0499
NP \times stocker			0.1275	0.1472	0.0218	0.0315
AP \times finisher			0.1243	0.2900	0.0151	0.0301
SE \times finisher			-0.4107	0.5351	-0.0157	0.0248
NC \times finisher			0.7682**	0.2244	0.0019	0.0556
NP \times finisher			0.4672*	0.1838	0.0951*	0.0467
AP \times harvested acres	0.0165	0.0673				
SE \times harvested acres	-0.0335	0.0695				
NC \times harvested acres	0.0080	0.0887				
NP \times harvested acres	0.1591*	0.0909				

Table II.
Results of the
DuPont seemingly
unrelated regression

Notes: AP, Appalachia; SE, Southeast; NC, North Central; and NP, Northern Plains. Instrumental variables are used for operator off-farm and spouse off-farm. *, **, ***Significant at 0.10, 0.05, and 0.01 levels, respectively

Harvested Acres as a positive driver for ROE for cow-calf farms. Though *Cows* was not significant in the profitability equation, *Cows \times North Central* and *Cows \times Southeast* variables were significant, suggesting greater cow-calf size economies to be realized in the *North Central* region relative to the *West* and lower size economies in the *Southeast* relative to the *West*. As shown in Table I, farms in both the *Southeast* and *North*

Central regions had fewer cows than farms in the *West*, which is consistent with the *Cows Southeast* result. McBride and Mathews (2011) showed that, though Western farms had more cows than *North Central* farms, net farm incomes for the two regions were similar, but greater than net farm income in the *Southeast*.

Specialization had a significant influence on financial viability of cow-calf farms. The *Proportion Beef* result indicates that diversification in beef production leads to greater asset efficiency, suggesting there are other farm enterprises that are complementary with beef production. The cross-effects of *Proportion Beef* with the regional variables in the asset efficiency equation, however, suggest that asset efficiency of farms in the *West* suffers the most from specialization in beef relative to the other US regions. The greater profitability of more specialized farms in the *Appalachia* and *Southeast* regions relative to the *West* further suggests greater financial viability associated with specialization in those regions. Of interest is that, referring to Table I, Western farms were the most specialized in beef. Overall, specialization in beef appears to be a negative driver for ROE for cow-calf farms.

Vertically integrating into the *Stocker* and/or *Finisher* phases had limited impact as shown in the main effects – farms that finished animals were more solvent than those that did not. There were, however, some differential impacts at the regional levels, with *Northern Plains* farms that finished animals experiencing lower solvency but greater asset efficiency than Western farms and *North Central* farms that finished animals experiencing greater asset efficiency than Western farms. The lower solvency and higher asset efficiency of farms finishing animals in the *Northern Plains* suggests these farms are more leveraged, but are realizing greater sales relative to their total assets. Though *Stocker* was non-significant in any of the main effects, results suggest that *North Central* operations vertically integrating into the *Stocker* phase were more solvent than those similarly vertically integrating in the *West*.

Operator and spousal off-farm work had significant impacts on farm financial viability. The positive impacts of operator off-farm work on profitability and solvency suggest that operator off-farm work is complementary with cow-calf farming, a result that is supported by Gillespie and Mishra (2011), who found that producers who work off-farm are more likely to produce beef relative to other enterprises. Furthermore, the solvency result suggests that operator off-farm work is used to supplement the farm enterprise financially.

Farms where the spouse worked more hours off the farm had greater asset efficiency. This is consistent with work by Mishra *et al.* (2012), who found that off-farm work was a positive driver of asset turnover for US farms. Results further suggest that in cases where a spouse worked off the farm, the farm experienced lower solvency. This impact is different from that of operator off-farm employment, and could be the result of the farm needing to have a spouse working off the farm to supplement household income and improve solvency while the operator concentrates on farm work. Overall, results suggest that spousal off-farm work is a positive driver for ROE on cow-calf farms.

Age was significant in all three equations. The results suggest that older producers were more profitable than younger ones, likely the result of greater experience, and more solvent, not taking on more debt as they age. Older farmers were, however, less asset efficient, suggesting that though they had accumulated a large asset base, sales relative to that asset base were lower. Since *Age* was significant in all three equations, we calculate the impact of *Age* on ROE as the sum of the three *Age* parameter estimates: -0.97 . This suggests lower ROE for older cow-calf producers relative to younger producers.

We find that greater use of advanced feeding technologies and general farm management practices led to higher asset efficiency. Use of advanced breeding technologies led to higher solvency while farms using advanced feeding technologies experienced lower solvency. Of interest is that economists often focus on the impact of technology adoption on profitability, but these results suggest that other financial drivers may be more heavily impacted by adoption. More extensive general adoption of technology had a greater impact on asset efficiency but a lower impact on profitability in *Appalachia* than in the *West*, suggesting that there are some differential financial impacts of technology by region. Overall, feeding technologies and general farm management practices appear to be positive drivers for ROE on cow-calf farms.

Conclusions and discussion

Results of this study suggest the main drivers of higher ROE in US cow-calf production to be: first, region, where a number of regional differences are noted for profitability, asset efficiency, and solvency, with the *North Central* (at 3.1 percent) and *Northern Plains* (at 3.6 percent) regions having the highest returns on equity; second, number of harvested acres on the farm, which led to higher asset efficiency in general and higher profitability in the *Northern Plains*, thus providing a strong boost to ROE levels there; third, diversification of the farm, which led to greater asset efficiency, particularly in the *West*; fourth, operator off-farm work, which led to greater profitability and solvency, on balance driving ROE up in all regions; fifth, spousal off-farm work, which led to greater asset efficiency (but lower solvency); and sixth, adoption of technologies, where feed technologies led to greater asset efficiency (but lower solvency), advanced farm management practices led to improved asset efficiency, and advanced breeding practices led to greater solvency. Of these factors, those for which the producer can make short-term adjustments include off-farm work decisions and adoption of technologies. Longer-term adjustments can be made for farm diversification. It is noted that results for *Harvested Acres*, *Proportion Beef*, *Operator Off-farm*, and *Spouse Off-farm* consistently suggest that income diversification on both whole-farm and farm household bases leads to greater ROE for cow-calf farms.

Factors appearing to have generally lower impact on cow-calf farm ROE were among those that have been the most highly touted as impacting farm returns and those which the producer has substantial control over: the number of cows included in the operation and whether stocker or finisher operations were included. While greater cow numbers improved profitability in the *North Central* region, the impact was not great suggesting relatively low impact on profitability. Most previous studies have examined economies of size without holding other drivers constant. However, larger farms also generally adopt more advanced technology and management practices, some of which can be argued to be scale-neutral, that result in heavier weaning weights (McBride and Mathews, 2011), and thus likely greater returns. While having stockers and finishers showed no impact on profitability and asset efficiency in the main effects, finishing improved asset efficiency in the *North Central* and *Northern Plains* regions relative to the *West*, suggesting that areas with quality forage and feed sources can improve asset efficiency by vertically integrating.

Our results on regional differences in use of stockers and finishers may have policy implications relative to the ethanol program. To the extent that the ethanol program increases the cost of grain, our results suggest that policies relaxing the ethanol mandate in drought periods would marginally benefit cow-calf producers diversifying into stockers and finishing cattle, particularly in the North[3]. On the other hand, an

increase in harvested acres was a positive driver for profitability and asset efficiency, suggesting that farms with greater land suitable for crops and hay had higher returns to equity[4].

Notes

1. DuPont analysis can be adapted to include owner withdrawals. Higher withdrawals from farm business earnings mean lower retention rates, which reduce potential growth. This extension is referred to as the Higgins approach which explicitly incorporates growth into the DuPont model (see Escalante *et al.*, 2009). We do not estimate the Higgins growth model in this work. However, using the results of the DuPont analysis combined with withdrawal data, we are able to evaluate the growth potential of farm businesses using three important drivers of growth – profitability, asset efficiency, and leverage. Recent ARMS data show that US farm withdrawals have ranged from 45 to 55 percent. Higher withdrawals mean lower retention rates, which reduce potential growth. For example, we find higher withdrawals in the West compared to other cow-calf regions in 2008.
2. Application of the DuPont expansion (decomposition of earnings) is dependent on the multiplicative nature of the expression. Given that the expression is an identity, it holds at every point with strict equality. We further assume that each ratio is log normally distributed. The logarithmic transformation yields an additive system of variables amenable to analysis using the normal distribution (Mishra *et al.*, 2009).
3. In a recent study, Babcock estimated that corn prices would drop an average of only 28 cents across a range of corn yield outcomes due to a full waiver of the mandate. As reported by the *New York Times* (2011) cow-calf “producers have been grappling over the half dozen years or so with rising feed prices as ethanol producers drove up the price of corn, and with drought that has parched grazing land and deprived their animals of water.”
4. Recent trends in cow-calf production reflect how resource base differences across regions played out given drought condition in major cow-calf production regions (Peel, 2013, *Wall Street Journal*, 2013). USDA data indicate that that beef cow numbers have dropped ten percent since 2008, from 32.435 million head to 29.295 million head, a 60 year low (US Department of Agricultural, National Agricultural Statistics Service, 2009, 2013; *Feedstuffs*, 2012a, b). The Western states led the way with a 1.7 million head reduction, followed by the Southern states with 1.1 million and the Northern states with only 0.5 million (with all of the decline in Kansas and Missouri).

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Further reading

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Appendix

Independent variables	Operator off-farm hours		Spouse off-farm hours	
	β	SE	β	SE
Constant	26.5267***	2.0957	2.4568***	0.6121
Age	-5.5241***	0.4474		
Farm net worth	0.0001	0.0006	-0.0006	0.0001
Government payments	-0.0213***	0.0060	0.0045	0.0011
Acres operated	-0.4812***	0.0740	-0.2286**	0.0936
Operator college degree	0.3639*	0.1845		
Spouse college degree			1.3220***	0.2365
Household size	-0.1674**	0.0945	0.6268***	0.1224
Accrued interest	-0.0029	0.0085	0.0360**	0.0148
Interest income	-0.0027**	0.0011	-0.0012	0.0043
Population accessibility	-0.0009	0.0010	-0.0017***	0.0005
Value of livestock production under contract	-0.0013***	0.0004	-0.0001	0.0003
Household assets	-0.0017	0.0025	-0.0025	0.0081
Household well-being	0.6933***	0.1114		
Adjusted wage			0.0095**	0.0046
Total animal units	-0.0005	0.0007		
Ratio of owned to operated acres			-0.5485***	0.1411

Notes: *, **, ***Significant at 0.10, 0.05, and 0.01 levels, respectively

Table AI.
Estimated regression
results for operator
off-farm hours

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